Wireless User-computer Interface Platform for Mental Health Improvement through Social Inclusion

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Abstract. Loss of communication due to long-term neurological conditions leads to isolation and loneliness. Individuals in these conditions raise the risk of depression, since they can't convey their needs and wants and loose their social networks. This paper describes the development of a wireless platform for user-computer interface, targeted at mental health improvement through communication and social inclusion. We describe the proposed approach in the context of an input device based on a single channel electromyographic signal, although the use of other biosignals is discussed to expand users' possibilities. Users' needs in terms of user interface implementation are considered, concerning severe speech and physical impairments.

1 Introduction

There are several neurological conditions in which affected individuals dramatically loose generalized motor control (e.g. brainstem stroke, motor neurodegenerative diseases, cerebral palsy, traumatic brain injuries or spinal cord injuries) [1]; [2]; [3].

Severe motor limitations often cause motor speech disorders and consequently severe difficulties in communicating. Communication loss will raise depression factors in user, due to isolation and loneliness [4]; [5]. Moreover it will difficult clinical support, since individuals cannot express symptoms and needs. In these conditions, if there is no effective technology for enabling the user to communicate, communication will be restricted to yes/no answers, which represent a great limitation to several important aspects in a person's life, as expressing needs and wants, decision making and social closeness[6]; [7]. Recognizing and addressing communication disorders is then of utmost importance.

Concerning communication disorders, access to Information and Communication Technologies (ICT) is important, since it offers means for providing social and emotional support, beyond space and time constraints caused by severe speech and physical impairments [7]; [8].

In this context, the great challenge is finding a user-computer interface that the user can control with autonomy, efficiently and consistently [1]; [9], in spite physical

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impairments. Efficient control of a user-computer interface will make possible for the user to break isolation and total dependence through access to the computer (e.g. user could independently control a virtual keyboard to access to the Internet).

Our work presents the development of a wireless platform targeted at mental health improvement through social inclusion. We describe the application of the proposed platform to a single channel user-computer interface, based on electromyographic (EMG) signal control. Important aspects concerning users' needs and technology development are presented. New possibilities to connect other types of sensors are discussed. The rest of the paper is organized as follows: Section 2 outlines the needs faced by the target user groups; Section 3 describes the proposed approach; and Sections 4 and 5 present the discussion and main conclusions.

2 User Needs

Concerning severely speech and physically impaired (SSPI) users, the following characteristics were considered in implementation of the presented user-computer interface:

(a) Mobility – wireless sensors allow user to be in a confortable position or move independent from the place where the computer is.

(b) Biofeedback – developed software includes the possibility to go through a training period, where the user can watch and learn to control its own signal (EMG) using biofeedback. In case of individuals in rehabilitation process, this tool is useful for the clinicians to evaluate the best place for the sensors and to explore new muscles.

(c) Personal solution – the user can operate with the system in his/her own personal computer and choose the software that will receive the events from this interface.

(d) Communication – it was developed a specific connection between our platform and a specific software for Augmentative and Alternative Communication (AAC) and Computer Access (©The Grid 2, from Sensory Software), aiming to provide specialized features for user communication.

3 Proposed Platform

3.1 EMG Signal Processing

The electromyographic signal is a record of the electrical activity generated by muscle cells when they are electrically or neurologically activated. For the detection of the EMG natural activation, the signal is usually rectified and filtered to obtain its envelope [10] or processed using statistical based methods [11].

In this work, the EMG data is collected and processed at real time using Python [12] with the NumPy [13] and PyWin [14] packages. The processing procedure consists in removing the sensor offset value and rectifying the result. To extract the signal's envelope, a smoothing filter is applied to the rectified signal.

Fig. 1. Representation of the communication process.

When the muscle is activated, the amplitude of the EMG envelope increases and if it surpasses a defined threshold, the initial instant of muscular activity is accepted after validating it for sporadic activations - by checking if the end of the activation was at least 100ms after the start of the activation. If accepted, the voluntary activation is converted into a triggering event to control an external predefined software (e.g. a virtual keyboard software). This voluntary activation can be configured as a Windows keyboard event or a software specific event (implemented for ©The Grid 2, Sensory Software), and is sent through Windows Messages [15]. A block diagram representative of the overall communication flow is presented in Figure 1.

3.2 User Interface

A web-based application was developed in order to provide a user-friendly tool to visualize the signals in real time, store the specifications of the software and provide feedback concerning the muscle activations.

The application is independent of the external software to which the signal activation is sent. In the application configurations it is possible to choose the specific software to which events will be sent – keyboard events (e.g. *enter* or *space key)* or software-specific events previously registered with Windows Messages.

As the application starts, the signal is graphically displayed on the screen. The threshold that sets the activation level necessary to accept the event is defined after signal calibration. After pressing the calibration button, the subject has to perform a few muscle activations and the threshold is defined as a third part of the maximum contractions' mean value. As the amplitude of the EMG signal may decrease with muscle fatigue for long acquisitions, a slider bar provided in the web interface enables the manual adjustment of the threshold value.

When the muscle is active and surpasses the defined threshold, the event is sent to the external software. To indicate that activation, a visual feedback is shown in the interface. A screenshot of the web interface with the functions here described is presented in Figure 2. This single event will activate a scanning process [1] by which the user can select a virtual key (containning a character, a text message or other types of commands to access to computer) in a virtual keyboard.

4 Discussion

Our work was focused on creating a wireless user-interface platform based on a single-channel biosignal onset detection, which can operate signals from a variety of electrophysiological or biomechanical sources. We presented an embodiment of this platform that produces the necessary events for manipulating a virtual keyboard. We worked with surface EMG sensors, which can be placed anywhere in the body.

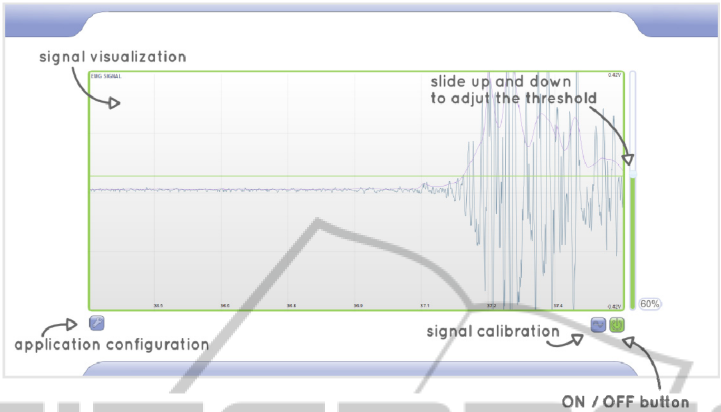

Fig. 2. Web interface and its functionalities.

An alternative to the presented EMG sensor, and for detection of specific eye movements, would be an electrooculography (EOG) sensor, which has a higher gain than the EMG sensor and can be suitable for low muscle electrical activity.

A relevant approach would be to combine different miniaturized and unobtrusive sensors to capture and send different types of events. An electroencefalography (EEG) sensor could be used in the occipital region of the head to capture EEG alpha rhythm, which appears after eye closure [16]. The event created through this mechanism could be used for other functions like starting or shutting down the application or switch between menus.

Tests are being made in real scenarios with SSPI users. This will be important to solve real problems arising from user-computer interaction.

5 Conclusions

Accessibility to ICT is important to SSPI individuals since it breaks isolation and restores the ability to communicate, which has a major impact on mental health of the users. Access to a computer may allow these individuals, not just to express needs and wants, but also to restore social roles and access to assisted living services.

A wireless platform and user-computer interface was developed taking into account users needs, in the context of severe motor limitations. We described an application of the proposed approach to the use of EMG sensors, which allow users to control the computer using minimal muscle movements. Connection to a specific software for AAC and Computer Access was considered in this work, fulfilling users' specific needs for Communication. Future work will focus on real-world validation of our system both with EMG, and other biosignals, which can be seamlessly introduced in our platform to expand users' possibilities.

By opening a way to ICT, our work can be helpful in sustaining and expanding social networks, reducing isolation then challenging multiple mental health factors affecting the target user groups.

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